X–ray observations of Mkn 421 with USA

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Abstract. This paper presents the first AGN detections with the USA X-ray detector on board of ARGOS. We started observing the BL Lac object Mkn421 at the end of January 2000, when it was also observed by the CAT Čerenkov telescope (see Pierre Espigat, these proceedings), and optical telescopes (but the latter are not presented here). Mkn421 was at the beginning of a long period of high activity that lasted for many weeks. Some observations on Mkn421 were also carried out in this period by XTE (see Rita Sambruna, these proceedings).

THE USA X-RAY DETECTOR

Description

The USA Experiment is an X-ray timing experiment with large collecting area and microsecond time resolution. USA is one of nine experiments aboard the Advanced Research and Global Observation Satellite which was launched February 23, 1999. USA is a collimated proportional counter X-ray telescope with 1000 cm^2 of effective area sensitive to photons in the energy range 1–15 keV. For an overview of the USA instrument, capabilities and detailed scientific observing plan see [1]. Briefly, the principal targets for USA are X-ray binaries whose X-ray emitting members are neutron stars, black holes or white dwarfs. A fraction of the observation time was devoted to observations of AGNs during multi-wavelength campaigns with TeV ground-based telescopes, since some BL Lac objects such as Mkn421 and Mkn501 are known to be X-ray emitters and since the X-ray emission is expected to be correlated with other wavelength emissions in some emission

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models. Another intensive multi-wavelength campaign with interesting results was conducted in 1998 [2].

Observations were done in low background regions of the orbit, where the counting rate was approximately 30 cts/s or 1% of the Crab level in the same conditions.

Observation Types

The USA X-ray detector was turned towards the Mkn421 BL Lac object on the occasion of an ASM and TeV ground-based telescopes flaring alert in January 1999. The observations started on January 29 and lasted for 6 months with three different types of observations.

- The first type of observation was the *drift scan* where the detector is pointing a few degrees off the source and then drifts through it until it is a few degrees away. This type of observation is a legacy from the pointing calibration method that was used on some point-like sources. This sequence was repeated several times within one observation that lasted for approximately 500 seconds (left panel in Figure 1).
- The second type of observation is called the *ping* mode where within one observation the source is observed for T_{ON} seconds and then a background is taken for T_{OFF} seconds (see right panel in Figure 1). Seconds of observation where the background is too high, especially at the beginning and the ends of an observation, are rejected. This type of observation provides better X-ray statistics and allows better spectral studies of the source. Some of these ping observations were done in the spectral mode which has the same energy range but 48 channels instead of the usual 16.
- Some pointed observations were also carried out. They provide more source X-ray photons, but they also rely more on a background *model* rather than on the frequent background measurements that are obtained in the previous observation type.

OBSERVATIONS OF MKN421

As mentioned above, Mkn421 was the first BL Lac observed by USA. The observations began after the flaring started, so an important piece of information is missing. The public ASM data are used to fill the lightcurve up to the date where USA started observing (Figure 2). The figure ends where the TeV observations had to stop due to the Moon, but the USA observations extend well beyond that point and will be presented in a future paper along with the TeV and optical lightcurves that are not shown here. The X-ray lightcurve (Fig 2) shows 6 peaks. The luminosity near the maxima reaches as high as 30 mCrab, and there is a clear tendency

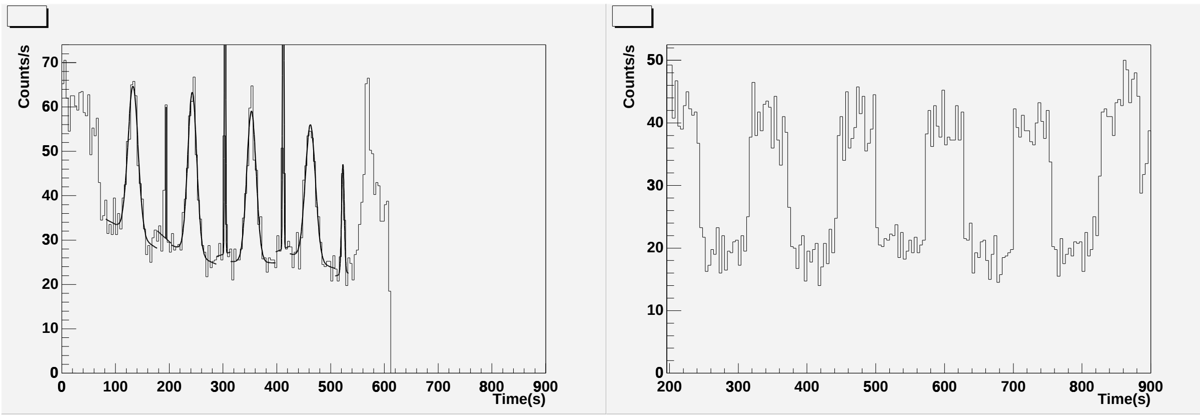

FIGURE 1. Left: aspect of a typical drift observation on Mkn 421. The signal appears on top of the background. The signals are fitted by a simple gaussian function plus a 1st order polynomial that accounts for quasi-linear changes in the background. The rewind scans across the source more rapidly than the drift, accounting for the fact that broad and narrow responses alternate with one another.Right: Ping observations of the same source but on a different day. There are 5 apparent ON and OFF of approx. 60 seconds each in this observation. This mode allows better photon statistics than the previous one.

for the timescale for decay after maximum to be shorter than the rise time, particularly on the third of the peaks. This is similar to some modes that are seen in microquasar sources (see Felix Mirabel, these proceedings), particularly GRS1915, although on a very different energetic scale and probably with different physical origins (the jet for Mkn 421 and the accretion disk for GRS1915). To explore this idea further, the lightcurve is subdivided into 6 parts where a peak-to-valley ratio of approximately 2 exists between high and low activity. The parts were fitted by a function of the form

$$R(t) = A\exp(-|\frac{t - t_{max}}{\sigma_{r,d}}|^{\nu}) \tag{1}$$

which is commonly used for fitting gamma-ray bursts lightcurves. It is a pulse function with different rise and decay times σ_r and σ_d and a peaking time t_{max}. The fit confirms that in all six segments the fitted rise time is usually longer than the fitted decay time and never is shorter than the decay time. Furthermore the fitted times and amplitudes of peaks allow us to look at the delay between successive peaks as a function of the amplitude of the earlier peak (bottom panel of Figure 2). There is an indication for a decrease in time between two flares as the intensity increases. In microquasar flaring episodes higher amplitudes correspond to a longer period. This interpreted to be a longer delay for resplenishing the inner part of the accretion disk that fell into the black hole. Therefore it is difficult to associate the AGN flaring mechanism with this simple model if the delay-intensity correlation is true.

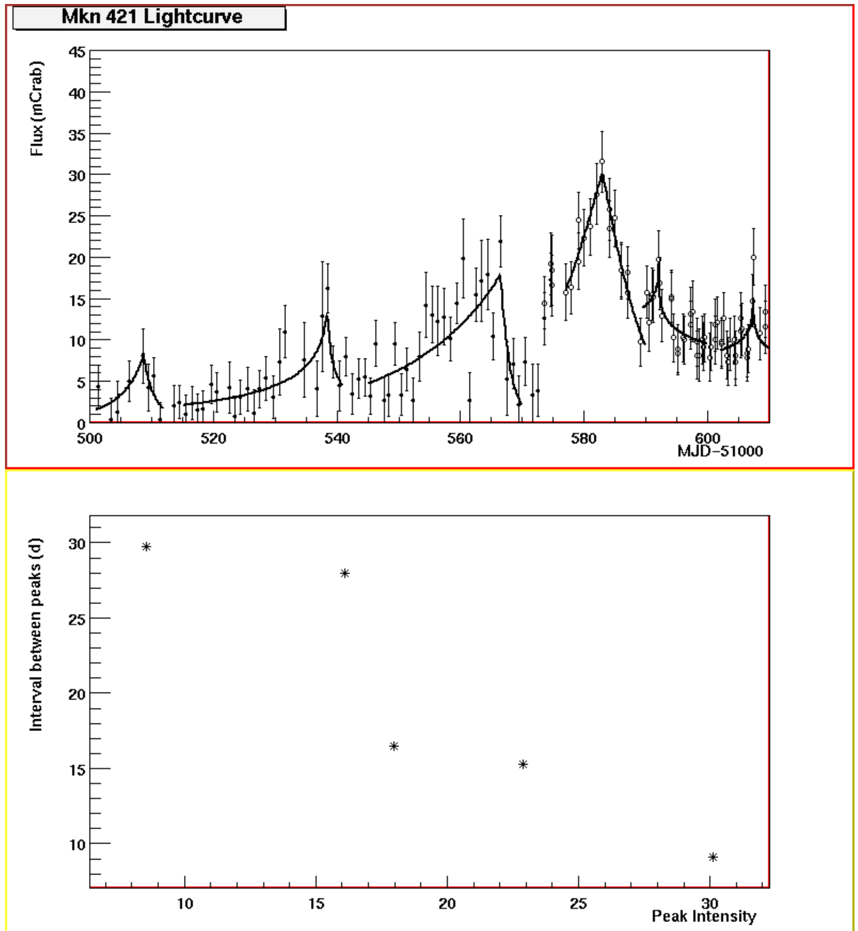

FIGURE 2. Top panel: lightcurve of Mkn 421 using ASM data (black dots) and USA data (open dots). The six different regions were fitted by equation 1 that accounts for different rise and decay times. Bottom panel: interval between peaks as a function of the intensity in the earlier peak. There is an indication of a decrease in the time separating flares as the intensity increases.

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